# C-Arm Cone Beam CT in BPH

Techniques and considerations for the safe treatment of benign prostatic hyperplasia.

**BY MARC SAPOVAL, MD, PhD; JOHANNA DAROLES, BSc; HUGO RIO TINTO, MD; MASSIMILIANO DI PRIMIO, MD; NICOLAS THIOUNN, MD, PhD; AND OLIVIER PELLERIN, MD, MSc**

Benign prostatic hyperplasia (BPH) usually consists of hypertrophy of the transition zone of the prostate, which in itself compresses the prostatic urethra and compromises voiding of the urinary bladder. The incidence of BPH is very high, and symptomatic patients are usually referred for prostatic reduction using transurethral ablation or open prostatectomy. These techniques carry their own risks of morbidity and mortality—the main ones being ejaculation disorders and impotence.[1]

Embolization has been demonstrated to be efficient in providing significant volume reduction, as well as a clinical effect on voiding. The technique consists of superselective catheterization of both prostatic arteries and flow-directed injection of particles until there is angiographic evidence of flow reduction or total occlusion of the target artery.

While developing this technique, pioneering interventional radiologists in Portugal and Brazil have done extensive work on the anatomical supply of the prostatic gland.[2] Anatomical description of the arterial supply has been reanalyzed and rationalized for the specific needs of intra-arterial navigation and intervention. In fact, the main challenge is to appropriately identify the arterial feeders to the prostatic gland, which consist of one prostatic artery on each side, arising from a common vesico-prostatic trunk, or the presence of two independent branches on each side (ie, anterolateral and posterolateral).

> It is of utmost importance to master this anatomy and to be able to recognize these features before performing embolization.

## ANATOMIC VARIATIONS

Multiple anatomical variations have been described and can be classified in variable origins of the prostatic artery, on one or both sides, but also in cases when the prostatic arteries carry a branch feeding the bladder, the lower part of the rectum/anal canal, or the corpus cavernosum. It is of utmost importance to master this anatomy and to be able to recognize these features before performing embolization. Unfortunately, this is new territory and, most of the time, interventional radiologists are performing prostatic embolization in rescue cases to treat actively bleeding lesions that are easily visualized during selective angiography. Therefore, the choice of which artery to embolize is simplified, and complications, even if they are very uncommon, will be better handled because there is basically no other alternative.

When shifting to BPH, the challenge is much more difficult. The reference technique is transurethral ablation (or other ablative technology), with well-described complications and a wealth of experience in the hands of hundreds of urologists around the world. It gener-

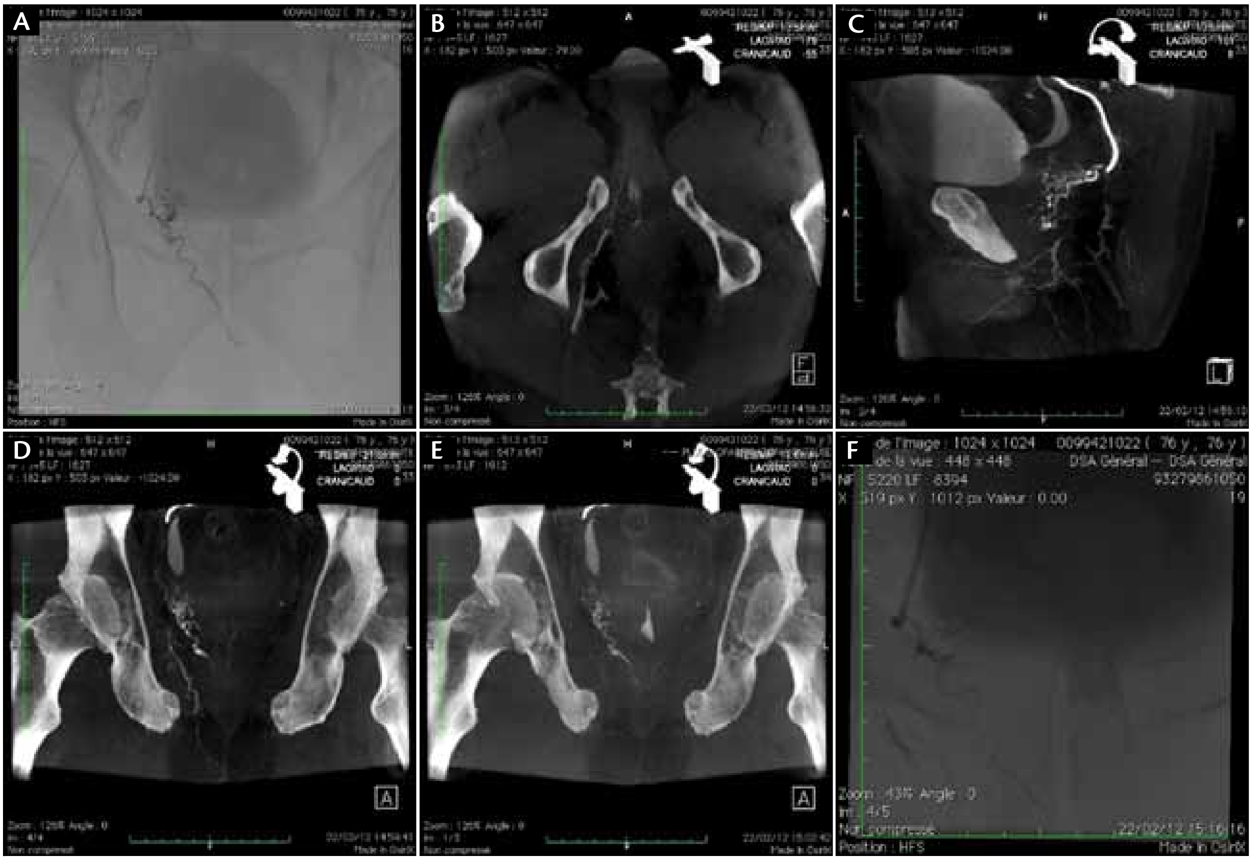


**Figure 1. Case 1: Avoiding embolization of the internal pudendal artery. Digital subtraction angiography runs showing opacification of the right prostatic artery with suspicion of accessory pudendal artery (A). C-arm cone beam computed tomography (CBCT) in axial maximum intensity projection (MIP) (B). CBCT in sagittal MIP (C). CBCT in coronal projection confirming the anatomy (D). CBCT after more distal injection only into the prostatic branch (coronal) projection (MIP) (E). Final angiography after embolization showing a preserved accessory internal pudendal artery (F).**

ally poses no technical or anatomical challenge, and to compete with this technique, embolization has to be performed in the safest possible way.

## IMAGING AND TECHNIQUE

Angiographic imaging using the conventional technique provides optimal spatial resolution and allows for visualization of the prostatic uptake of contrast when the prostatic artery is selectively injected. However, because of a lack of three-dimensional visualization, even the best subtracted angiography does not allow for confirmation that the contrast uptake achieved during superselective injection on one side feeds the median lobe and only the median lobe. It is especially difficult to diagnose feeding of the bladder, the lower part of the rectum/anal canal, and the corpus cavernosum. Unfortunately, this is the main risk of this intervention, and the occurrence of untargeted organ embolization could theoretically be damaging to the patient. Experts have reported few complications, such as vesical or rectal ulceration.[3-5] Although they did not report significant rates of morbidity, theses complications could increase when the technique is performed by less-experienced operators.

We seek to demonstrate that modern imaging using flat-panel detectors can help to make this complex embolization technique safer and more reliable. The classic angiographic technique can now be refined with the use of flat-panel detectors, allowing CBCT to be performed. Because flat-panel detectors allow the creation of a uniform pixel signal without the geometrical conic deformation that is intrinsically related to a light amplifier, post-processing using complex software is possible. Moreover, rotational imaging that consists of a series of angiographic images acquired at hundreds of different projections allows three-dimensional image reconstruction of the arterial network and of the anatomical structure, just like conventional CT. This provides access to all three-dimensional imaging aspects, including fusion images.


**Figure 2. Case 2: Avoiding embolization of rectal branches. Digital subtraction angiography runs showing opacification of the right prostatic artery with suspicion of rectal branches (A). CBCT in coronal MIP (B). CBCT in axial MIP showing enhancement of the prostatic gland and contrast uptake of the anteroinferior rectal wall with the feeding rectal arteries (C). Angiography performed after embolization demonstrates maintained patency of the rectal branches and occlusion of the prostatic branches (D).**

We use C-arm Artis Zee angiography (Siemens Healthcare, Forchheim, Germany), and the intervention is performed using local anesthesia without the need for bladder catheterization, as the procedure is short. With regard to imaging protocol, after the prostatic artery has been identified in terms of origin using preinterventional CT angiography, the patient undergoes superselective catheterization, usually of the anterolateral branch using a microcatheter. Once the microcatheter is in place, an 8-second C-arm cone beam CT (DynaCT [Siemens Healthcare]) rotation is performed during slow manual injection of 10 mL of diluted contrast (2 mL of iodixanol 320 mixed with 8 mL of saline) using a 10-mL luer-lock syringe. To ensure optimal contrast uptake of end organs, the injection is started 2 seconds before rotational imaging and continued during the entire rotation, resulting in a total injection of 10 mL of the contrast mixture.

Real-time postprocessing of the images allows visualization of the cross-sectional anatomy of the pelvis with good spatial and contrast resolution. The viewing protocol uses a combination of 3-mm-thickness MIP in three planes and a volume rendering technique. The images generated by this approach show dramatic enhancement of the gland while the nontarget organs remain unenhanced.

After confirmation of the appropriate anatomical location of contrast uptake, embolization using the conventional technique (diluted spherical microparticles) can be safely performed.

## DISCUSSION

Based on four consecutive patients in whom we used this protocol, we have concluded that this approach could be of great benefit. All patients presented with BPH, an International Prostate Symptom Score > 18, and a prostate volume > 40 mL. Imaging from two patients in this series is shown in Figures 1 and 2.

This initial experience is very encouraging, but further work is needed. The unresolved issues at this time are the radiation load to the patient and operator, as well as the true clinical significance, which could only be demonstrated in a larger experience and, optimally, with randomization. In terms of technical limitations, one has to be aware that forceful injection in the microcatheter could lead to reflux of contrast during three-dimensional rotational imaging, which would then create misleading and unwanted uptake in other organs. In fact, manual injection during the 8-second rotational acquisition is not controlled using real-time fluoroscopy.

Manual injection is not easy to standardize, and the rate of injection can be variable. To overcome this limitation, we perform a short test injection under fluoroscopy, which is used to adjust the speed of injection. The same operator with the exact same syringe and contrast dilution will perform this test injection, as well as the injection during three-dimensional imaging, making it possible to assess the optimal injection rate. We have not yet explored the use of an automatic injector, which would likely result in a more reliable injection; however, this may not be practical due to the need for dilution and a microcatheter.

In terms of postprocessing techniques, embolization could be well guided using flow rate measurements during embolization to optimize outcomes. These tools are still a work in progress. If in the future these tools could be used to determine when to stop embolization (a common problem in all embolization procedures), interventional radiologists would have the ultimate weapon to use in the very promising field of BPH embolization.

## CONCLUSION

We believe that the approach described in this article allows increased safety during BPH embolization. It is

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simple to use and requires little postprocessing expertise. Interventional radiologists who want to develop their own BPH program should consider using these modern imaging techniques, especially at the beginning of their experience, to validate the correct catheter location for applying embolics. ■

*Marc Sapoval, MD, PhD, is with the Interventional Radiology Departments, Hôpital Européen Georges Pompidou, Assistance Publique–Hôpitaux de Paris and Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine in Paris, France. He has disclosed that he has no financial interests related to this article. Prof. Sapoval may be reached at marc.sapoval2@egp.aphp.fr.*

*Johanna Daroles, BSc, is with the Interventional Radiology Departments, Hôpital Européen Georges Pompidou, Assistance Publique–Hôpitaux de Paris and Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine in Paris, France. She has disclosed that she has no financial interests related to this article.*

*Hugo Rio Tinto, MD, is with the Radiology Department, Centro Hospitalar de Lisboa Central, New University of Lisbon in Lisbon, Portugal. He has disclosed that he has no financial interests related to this article.*

*Massimiliano Di Primio, MD, is with the Interventional Radiology Departments, Hôpital Européen Georges Pompidou, Assistance Publique–Hôpitaux de Paris and Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine in Paris, France. He has disclosed that he has no financial interests related to this article.*

*Nicolas Thiounn, MD, PhD, is with the Urology Departments, Hôpital Européen Georges Pompidou, Assistance Publique–Hôpitaux de Paris and Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine in Paris, France. He has disclosed that he has no financial interests related to this article.*

*Olivier Pellerin, MD, MSc, is with the Interventional Radiology Departments, Hôpital Européen Georges Pompidou, Assistance Publique–Hôpitaux de Paris and Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine in Paris, France. He has disclosed that he has no financial interests related to this article.*

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